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Welcome from the Editor

I am delighted to present the third edition of SURJ@UQ. It has been a pleasure to work with our authors and I thank all of them for their involvement. Particular thanks goes to Zac Pross who has done a tremendous job with the authors' pieces.

This journal gives students at UQ and beyond the opportunity to communicate about science for the pleasure of writing, rather than for assessment! Here at SURJ we always enjoy seeing what students want to write about when they have free choice (rather than an assignment to complete), and I hope you enjoy reading their contributions.

Susan Rowland (Editor in Chief, SURJ@UQ)

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Cover image: *LH 95 stellar nursery in the Large Magellanic Cloud. NASA, ESA, and the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration.*

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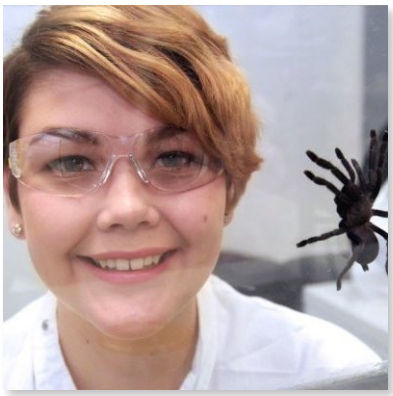
Interview with an Extra Terrestrial

The cosmic traveller I met in my backyard

Samantha Nixon

Sam completed a BBiomedSci (Hons) and is now pursuing a PhD at UQ.



It's a late Sunday afternoon, and a casual stroll through my backyard uncovers what could be an alien life form.

It has eight stubby legs directly below a plump, segmented body. Attached to these legs are bear-like claws that help it waddle across the greeny-brown expanse of mossy leaf-litter.

Beneath my microscope, this family of tiny, translucent invertebrates seem perfectly content. Granted, they would be just as comfortable at the bottom of the ocean or even in outer space.

I have before me a population of water bears, each roughly half a millimetre in length (about the size of a period at the end of this sentence).

They are remarkable.

Also known as a tardigrade (of phylum *Tardigrada)*, the water bear's cuteness is matched only by its indestructibility. There are over 1000 species and are found in almost any habitat on Earth. Terrestrial species are commonly found in soils, leaf litter, and mosses, while marine species make their homes in both salt water and fresh water.

On the inside, they seem much like us. They have muscles, a dorsal brain, and an alimentary canal digestive system; yet they are capable of surviving radiation levels hundreds of times greater than a lethal dose to humans. They can hop between 150 ºC and almost absolute zero with ease. Exposed to the vacuum of space? No problem. No water or food for several years? Too easy. Subjected to several Mariana Trench's worth of pressure? Still happy as a lark. The tardigrade ambles across all of these domains as if saying "give me a challenge."

This raises the question: how on *earth* (or indeed, elsewhere) do they do it?

Tardigrade. *Credit: Phineas Jones https://www.flickr.com/photos/phineasx/*

A Never Say Die Attitude

The most resilient survival adaptations are reserved for terrestrial water bears. Aquatic and marine environments are typically less susceptible to damaging environmental factors such as ultra violet (UV) radiation and temperature. Consequently, aquatic-dwelling water bears are significantly less hardy than their land based cousins.

Terrestrial water bears have been experimentally subjected to functional absolute zero environments (0.05 Kelvin or -272.95° Celsius) for as long as 20 minutes, and after being warmed and rehydrated were perfectly healthy. Even storing water bears for two years at -200° Celsius didn't disrupt them – nor did +150° Celsius.

Extreme pressures of 40,000 kilopascals (nearly 400 times greater than Earth's atmospheric pressure) similarly did not affect egg-laying or daily activities. Water bears can also survive extreme chemical stresses such as high concentrations of carbon monoxide and dioxide. They have been shown to survive extreme dehydration for 10 years. After 120 years of dehydration, one tardigrade moved a leg – although there is debate whether this constitutes surviving.

The tardigrade's pervasive durability has attracted significant scientific attention. In 2008, the Tardigrades in Space (TARDIS) project took off – literally. The European Space Agency (ESA) launched a number of tardigrades into orbit on the Russian FOTON-M3 mission with the aim of discovering whether the tough little critters could survive the harshest environment of all: outer space.

Four species were selected, all shown to possess extreme resilience to desiccation: *Milinesium tardigradium*, *Richtersius coronifer*, *Ramazzotius oberhaeuseri,* and *Echniscus tetsudo*. They were dehydrated, packed on the rocket, and sent into orbit.

Not only did they survive in the vacuum of space for ten days, they successfully reproduced upon returning to Earth. Some tardigrades even endured the intense solar, gamma and ionising radiation that comes with space exposure. And thus, along with bacteria and lichens, tardigrades are the first animal known to survive in space.

Die, Wake up, Feed, Breed

The water bear's trump card lies in its ability to shut down its own metabolic systems – a process called *cryptobiosis*. Cryptobiosis refers to a reversible state where metabolism is suspended in response to an extreme environment. For all intents and purposes, the water bear appears dead – but it isn't.

Terrestrial water bears are aquatic animals that surround themselves in a film of water, but live in terrestrial habitats. Mosses and lichens present a sponge-like, water-filled environment in which tardigrades love to bathe. However, mosses are susceptible to drying out, and the absence of liquid water presents a problem for the water bear.

Moss. *Credit: Andrew Hill https://www.flickr.com/photos/47042618@N06/*

Enter anhydrobiosis.

As the mosses dry out, so too do the water bears – losing a third of their size as they forfeit up to 97% of their water content. Metabolism grinds to a halt as the tardigrade minimises its surface area by tucking its head and legs under its body. This impenetrable ball structure is called a *tun*. It's a process comparable to removing all moisture until just the key ingredients remain – like the process of powdering milk. A tardigrade can reanimate out of its tun form when water is made available. It was in this tun form that the tardigrades of the TARDIS program successfully returned from space unscathed.

The tardigrade may enter anhydrobiotic states several times a year, and in these states they can survive almost anything. But even in anhydrobiosis, tardigrades are surprisingly sensitive to altered oxygen levels. Of course, the wily tardigrade has evolved a means to cope.

Oxygen levels can diminish when a water bear's mossy habitat is flooded with rain. In response, the tardigrade swells up like a Mr Stay-Puft Marshmallow Man, floating on the water until the moss dries out. Life in the absence of oxygen is called anoxybiosis – another form of cryptobiosis.

In a tun, tardigrades can also live under conditions of extreme cold. Cells are largely filled with a liquid called cytoplasm, and the freezing of this liquid will cause a water bear's metabolism to stop.

The problem is, cytoplasm is ~90% water, and since water expands when frozen, the process of freezing cytoplasm should rupture the surrounding cell. Not so in tardigrades. The most likely explanation is that tardigrades are able to produce molecules (cryoprotectants) that alter the temperature at which cells freeze, allowing for a slow and controlled entry into cryobiosis. Alternatively, the cyroprotectants may inhibit formation of ice crystals, allowing for easier thawing.

Extreme salinity poses no threat to water bears either. Marine tardigrades can overcome enormous osmotic gradients to maintain osmotic homeostasis. Others again rely on the trusty tun, which is impervious to osmotic exchange. Furthermore, ultra violet radiation usually harms DNA, yet tardigrades seem able to repair the damaging effects of their sunburn.

Waterbears at Saguaro National Park. *Credit: Katja Schulz https://www.flickr.com/photos/treegrow/*

The exact molecular mechanisms that enable tardigrades to readily and sustainably undergo so many forms of cryptobiosis remain a mystery. Perhaps a greater mystery lies in why these complex survivorship strategies have evolved in just the one type of organism?

To boldly go where no invertebrate has gone before

The Panspermia Hypothesis posits that life is distributed about the universe via planetoids, asteroids, and meteoroids. For successful interplanetary travel, an organism would need to combat the low pressures of space, persist for a long period without adequate oxygen or water, and endure the onslaught of ionising radiation beyond the planet's protective atmosphere. All of this sounds like an organism we know and love. So could the water bears have come from outer space?

Perhaps options for their home planet lie in Epsilon Eridani, a solar system approximately 10.5 light years away from our own. A cryptobiotic tardigrade could conceivably travel and survive on an asteroid from this faraway home…if its rocky vessel was traveling at close to the speed of light.

It seems unlikely, but there is another option - most terrestrial water bears are *partheno-genetic*. This means that they are able to produce eggs without mating. A few species can even self-fertilise as hermaphrodites. The 2007, 2008 and 2011 tardigrade space missions also subjected tardigrade eggs to the extremes of space. In many cases, the eggs were just as hardy as their parents.

So, it's possible that a lone tardigrade or an egg, persevering on a lump of rock hurtling through space could live until it reached a

suitable planet. Should it even reach a planet though, the tardigrade would need to contend with a scorching entry into the planet's atmosphere. Not to mention, you know, landing.

The Earth is showered with tons of particles from space every day – could an errant piece of space debris have carried a tardigrade?

At temperatures reaching up to 3000°C, a vessel that is less than 25 metres in length will burn up as it enters the atmosphere. Too large a vessel and a tardigrade will experience colossal Earth-colliding g-forces.

In either case, even the trusty tun would be hard pressed to survive that.

To make it to Earth, a tardigrade would have to be aboard a meteoroid greater than 25 metres (but less than one kilometre) in length. Once their rocky vessel entered the atmosphere, they would have to catch a ride on one of the fragments breaking off their space ship to avoid the damaging impact of collision.

Plausible, but still unlikely.

Nevertheless, water bears can be found almost anywhere you look on Earth: from the top of rainforest canopies to the depths of the ocean; from equatorial coastal shores to the Arctic tundra. If there's a habitat, there's a tardigrade.

So how did they get to be all around the world? Mostly likely via wind and water. As a tun, a water bear is similar to a dust particle or pollen. It could easily float to exotic places; and, if it lands in an unsuitable microenvironment, it has only to wait for conditions to become favourable and it can begin life again.

Early Earth. *Credit: NASA's Goddard Space Flight Center Conceptual Image Lab*

One small step for a bear, one giant leap for mankind

And so, from under my microscope back to their mossy home, I return my borrowed tardigrade family having developed a deep respect for this complex and intriguing animal.

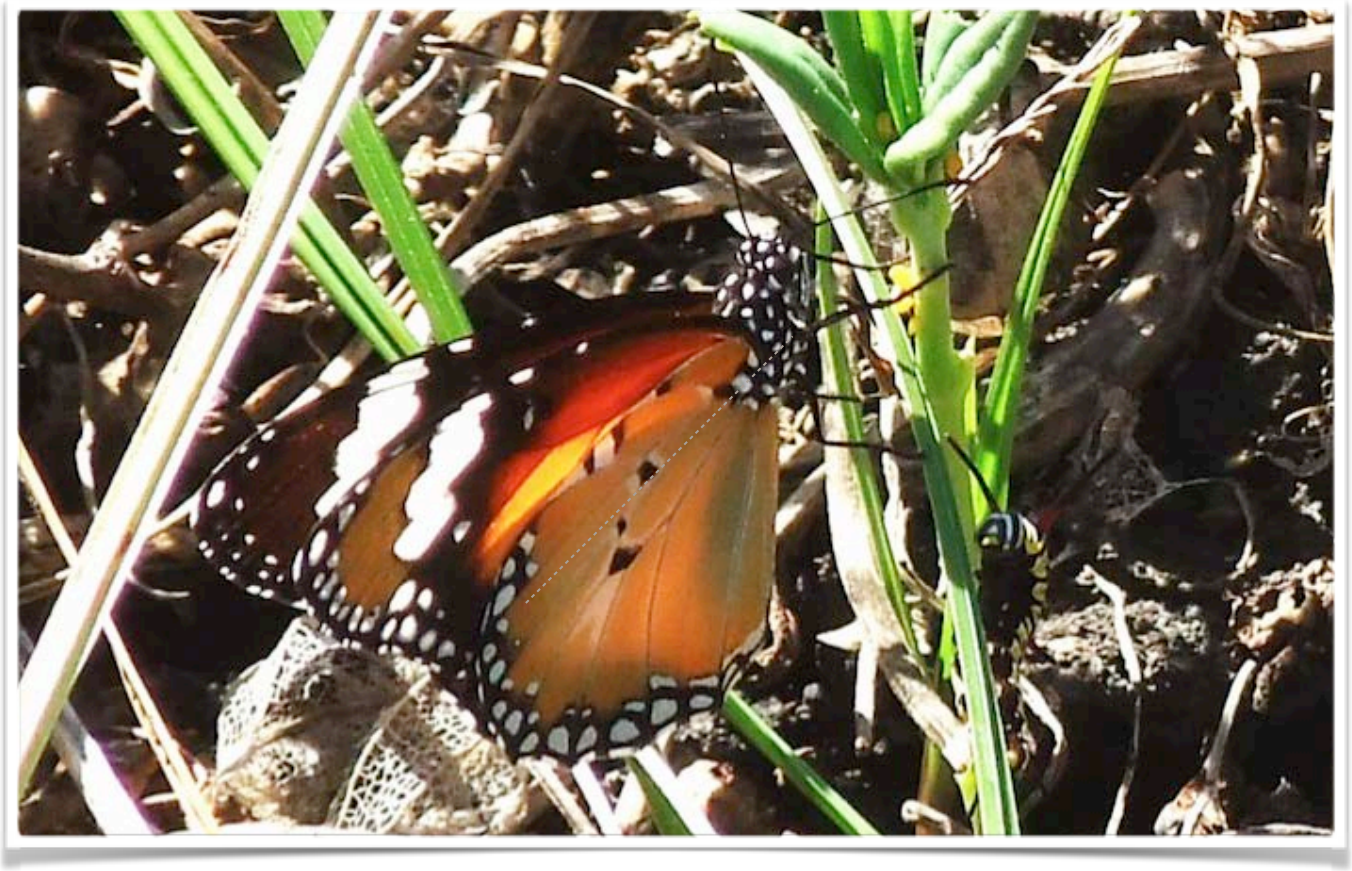
But the tardigrade's story doesn't end there: their polyextremophilic properties are opening new research opportunities – bettering our understanding of how cells respond to radiation and extreme salinity.

Who knows? Perhaps the trusty tun will teach us how to become interstellar travellers ourselves.

The Future Seeker

Aeryn Larkin

Aeryn is completing a BOHSS at UQ.



A garden scene; and what do we see? Resplendent in orange, white and black, a butterfly perches on a spike of grass. But lurking in the shadows is another creature - a caterpillar, sidling up to the butterfly as if in conversation and looking up in awe at what it is to become.

Although these two creatures appear quite different right now, they are in fact both *Danaus plexippus, o*therwise known as the “Wanderer Butterfly”, or the “Monarch Butterfly”. The species is reasonably common in the Brisbane area. It spends about two weeks feeding as a caterpillar before progressing to its pupal (chrysalis) form and finally transforming into a butterfly.

Unfortunately, many of the caterpillars don’t live to become butterflies because they end up in the bellies of wasps and fly larvae. On the other hand, the butterfly’s sole food source, milkweed, is poisonous – making the butterfly poisonous to birds and thus significantly reducing its list of natural predators. So, once the Wanderer reaches its final dazzling form, the only remaining predators are overzealous entomologists and car windscreens. Let’s hope the caterpillar makes it!

Superbugs and Mother Nature's Solutions

Kimberley Stirk

Kimberley was an international exchange student at UQ. She has now returned to the UK.

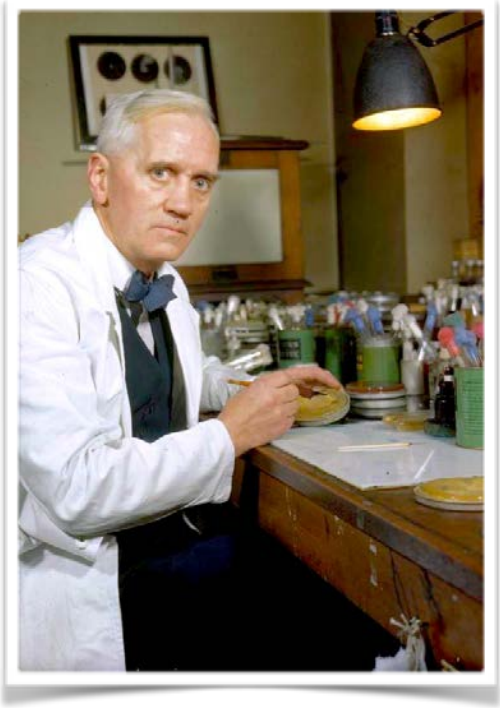
Antibiotics have been touted as miracle medicinal weapons since World War II, but pathogenic bacteria are now growing resistant at unprecedented rates. Over-prescription and poor course management have sent us hurtling out of the age of the wonder drug and into the era of the 'superbug'. In response to our carelessness, this new breed of pathogen has evolved resistance to most, if not all, known antibiotics.

Methicillin-Resistant *Staphylococcus aureus* (MRSA) is one such multi-resistant superbug. It can live and breed harmlessly on most people's skin but there are few antibiotics capable of treating the infection once the bacteria gets inside the body – and the list of usable drugs shortens with every year. A healthy immune system will usually contain an infection with ease. It is in the weak, the young, and the elderly that MRSA wreaks havoc. Hospitals are thus an unfortunate breeding ground for MRSA outbreaks, jumping from one weak immune system.

Researchers around the globe are desperately trying to forestall the post-antibiotic epoch and have begun searching Mother Nature for help. Some sweet-toothed scientists are staving off antibiotic resistance by looking to the antimicrobial properties of certain honeys.

Other scholars are transforming viruses into bacteria-killing mercenaries.

Can we swing the war back in our favour, or is it too late?



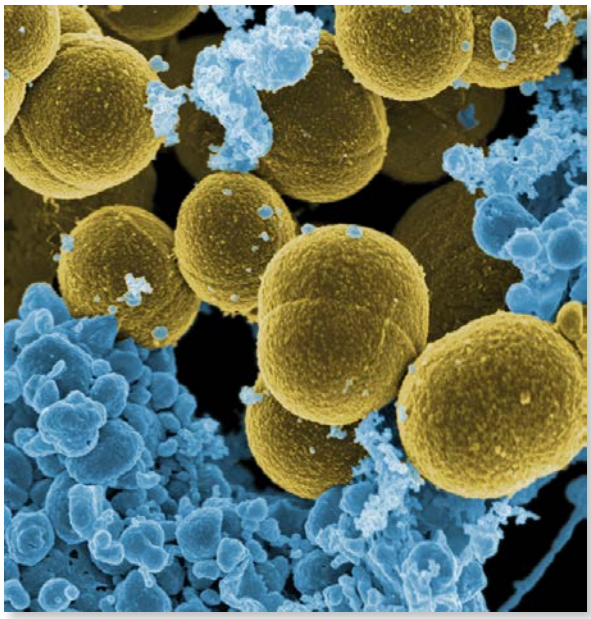
Credit: Imperial War Museum

"The time may come when penicillin can be bought by anyone in the shops. Then there is the danger that the ignorant man may easily underdose himself and by exposing his microbes to non-lethal quantities of the drug make them resistant". - Alexander Fleming

Superbug case study: MRSA

The symptoms of *Staphylococcus aureus. S. aureus* infection may be mild -- such as fever and small red bumps on the skin – but if left untreated, or treated incorrectly, deep abscesses can develop. The infection can become life threatening if it spreads to the respiratory system, circulatory system, or the bones and joints.

Penicillin proved an effective treatment against *S. aureus* in the early 1940's, but the bacteria



Staphylococcus aureus under the electron microscope. *The larger green cells are bacteria, while the smaller blue material is host organism tissue. Colours are artificially applied for clarity. Credit: NIAID/RML*

grew resistant before the decade was out. In response to the increasing number of cases of penicillin-resistant *S. aureus*, scientists created new drugs. But, under selection pressure, *S. aureus* acquired genes that prevented all penicillin-related drugs from binding to a key enzyme that builds the cell wall. The way we test for these genes is by challenging the bacteria with methicillin. If they are resistant, we call them MRSA.

These methicillin-resistant *Staphylococcus aureus* (MRSA) strains had far larger implications for antibiotic use than the previous penicillin-resistant strains. Now MRSA could not only evade penicillin but also other families of antibiotics, such as the cephalosporins. This broad range resistance created the MRSA hospital epidemic which continues to this day.

Vancomycin is one of the few drugs still able to treat MRSA, despite some strains of MRSA have become resistant (termed VRSA). It seems that the antibiotic era may truly be coming to an end. Now it is vitally important to find new ways of treating bacterial infections.

Using sweet Mother Nature – how honey can help us

Research has shown that New Zealand Manuka honey and Revamil® Source (RS) honey have high antimicrobial properties against many bacteria – including MRSA – and, after prolonged treatment, are yet to produce resistant strains.

A honeybee immune system molecule (Bee defensin-1), hydrogen peroxide (H_2O_2), and Methylglyoxal (MGO) were found to be the active components in RS honey. That is, after these components were neutralised, the honey's antimicrobial properties dropped significantly. When the pH was also neutralised, the honey's effects were reduced to that of an equivalent sugar solution, demonstrating that the broad spectrum action is due to multiple factors.

Manuka honey is slower acting than RS honey, but remains effective at lower concentrations. This has been attributed to the extremely high concentrations of MGO.

After the MGO was neutralised, however, the honey maintained its bactericidal properties – suggesting that Manuka honey relies on a range of components to destroy bacterial populations. Furthermore, various studies have demonstrated that Manuka honey can act synergistically with antibiotics – that is, Manuka honey mixed with antibiotics will have a greater combined effect compared to those of the individual agents.

Honey has antibacterial properties.

Credit: Don Hankins https-//www.flickr.com/photos/23905174@N00/

Viral aids

In addition to plant remedies, another potential solution to our superbug crisis has been found in the unexpected form of viruses. It is well known that viruses are able to cause disease among humans; however, bacteria may also fall victim to specialised viruses called bacteriophages.

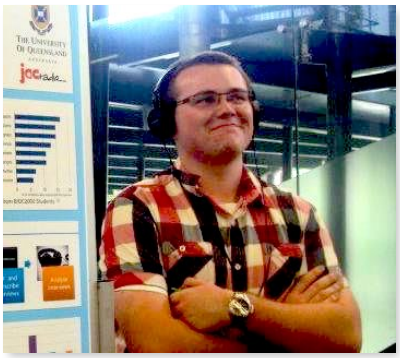
Although the existence of bacteriophages has been known for over a century, very little has been done to investigate their potential for bacterial infection control. Recently, new research has been carried out which aims to utilise bacteriophage enzymes called lysins. Lysins are used to break through the bacterial cell wall, enabling the bacteriophage to release its progeny. In breaking the cell wall, the lysins inadvertently cause bacterial death, inspiring researchers to use lysins in the treatment of bacterial infections.

One of the huge advantages of using bacteriophage lysins as antibacterial agents is that they infect only a specific type of bacteria. Antibiotics, on the other hand, are not selective and will often destroy whole populations of good bacteria. Lysins recognise the parts of a bacterial cell wall that are specific to an individual species; therefore, they could be used to target harmful bacteria while avoiding beneficial bacteria.

This is exactly what researchers did with the *S. aureus* bacteriophage ϕMR11. By purifying its lysin (MV-L) they were able to treat many *S. aureus* strains, including MRSA and VRSA, but without harming the resident bacterial populations.

The history and progression of MRSA signals some tough questions for our future: will we ever win the arms race against super-pathogens? Even with new and innovative antimicrobials clawing to the forefront, will bacteria continue to out-evolve our best efforts? If we are to win the war, research efforts must focus on finding alternative methods of beating back diseases and infections. Of course, Mother Nature will always provide the tools necessary to help us; we just need to know where to look.

Interview With a PhD Student (or Two)



Kurt Giuliani

Kurt completed a BBiomedSci Hons at UQ. He now works as a scientist for Queensland Health.

As I reached the end of my journey as an undergraduate student, I wanted to find out about career-paths other than medicine. I sat down with two PhD students - Baptiste Coxam and Sarah Sweet - and ask them about doing a PhD and the outcomes of PhD study. So let's find out what it takes to get those three coveted letters after your name.

Could you tell me a little bit about yourselves?

Baptiste Coxam: Hi. I'm an International Student from France working at UQ. I studied in Strasbourg for my undergraduate and masters degrees. After that I did some volunteer work and laboratory internships at the IGBMC (France) and New England Biolabs (USA) before I joined the PhD program here. I work on lymph-angiogenesis in zebrafish; I'm trying to understand how they can make new lymphatic vessels from their existing lymphatic system. We used to think that this only happened during embryogenesis, but it also happens in adult animals. It's especially pertinent to cancer, when new tissue is formed and provided with a circulatory system in an adult.

Sarah Sweet: And hello! I'm an Australian PhD student. I did my Science degree in Australia and then worked for eight years in a small business before I decided to come back to university. I enjoyed working, and I completed a Graduate Certificate in Research Commercialization but I needed more challenge in my life! I had to backtrack and do some advanced courses in physics and maths before I could join the PhD program at UQ. Now I'm an astrophysicist. I work with compact dwarf galaxies, which as the name suggests are very small compared to a normal galaxy, but very large compared to a cluster of stars.

How did you choose your project?

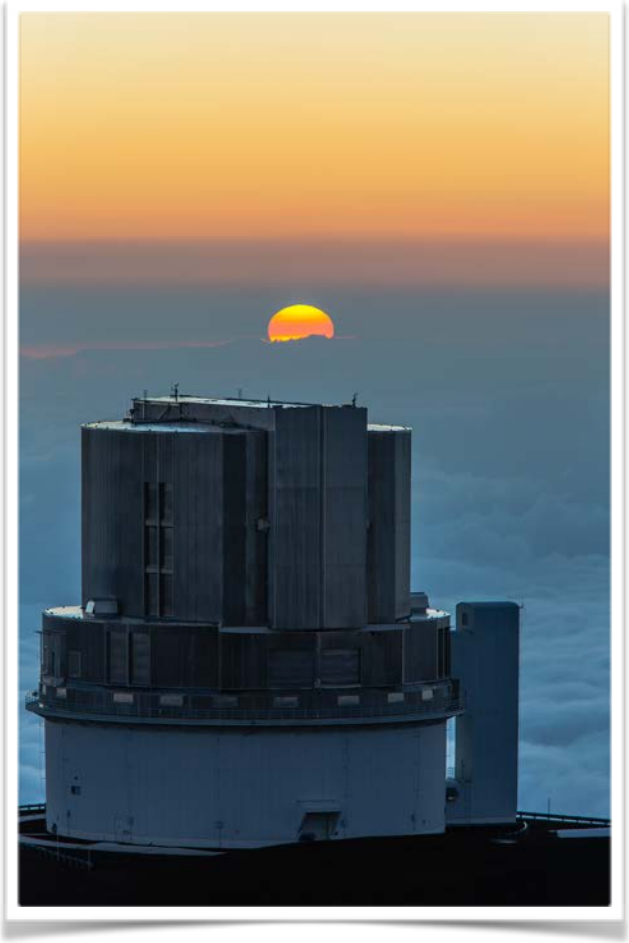
Baptiste: Pretty much by elimination, [it] came down to development as being the most interesting part of science for me. Before studying a PhD you need to ask yourself "*Am I moving into a field that is going to be of any relevance - will it actually lead to potential employment opportunities?"* When I was looking for a PhD, the field of lymphangiogenesis was sort of in a small boom and my supervisor was just starting his lab. I ended up in Australia kind of by an accident, because he was moving here, so I came too!

Sarah: I think that for me choosing the topic was a little bit serendipitous. I knew that I wanted to do research in astrophysics and I approached my supervisor about that. There was one other opportunity I could have taken, but this one stood out to me.

What do you guys do all day?

Sarah: Depending on what phase I'm working on at that time, things change. I go out observing, and, depending on how much time is awarded, that can be anywhere from one night to typically three or four, or sometimes more. That involves traveling to the telescope, usually, but sometimes I work remotely. I've just been allocated three nights on a telescope in Chile and one night on a telescope in Hawaii, which is very exciting.

What do I do - well, I set up in the afternoon, take some calibration frames, and at night I drive the telescope. Or if it's a big telescope that has extra support staff, then they're likely to be taking the observations. You will just be there, making sure they're taking what you want to see. Usually after that is processing the data. The idea is to remove all the effects of the telescope and hopefully also the skylines, clouds, water vapour, et cetera - they all interfere with the measurements you want to take. After that I take some measurements - how bright something is or how much calcium is in this particular star or galaxy, for example. Then I compare those measurements to the literature, write about it, and submit it to a journal to have it published.



The Subaru telescope, Mauna Kea, Hawaii.
Credit: Vadim Kurland https://www.flickr.com/photos/vkurland/

Baptiste: As a PhD student you do a lot of the same thing over and over again until [it] works. And [sometimes] the experiments [do not] give you the results that you're expecting, but at least they give you results. On a day-to-day basis, I take care of my fish in the morning, I check the genotypes or set up some

The zebrafish facility at the National Institutes of Health (NIH).
Credit: Uri Manor, National Institute of Child Health and Human Development, NIH

experiments with my fish and observe the results. As I'm working with transgenic fish where the whole vascular system is highlighted with different fluorescent compounds, I can actually treat them with different drugs or look at particular mutants under a fluorescent microscope, see if anything is going wrong and quantify all these things. It's also quite a bit trying to read the new literature in the field. So I'm pretty lucky in that regard that lymph-angiogenesis is not the field that is most active in the wordl!

The refreshing part of my day-to-day life is also to do some demonstrating at the University of Queensland. I just started demonstrating in genetics and in bio-cellular research. I'm also part of the ambassador program at my Institute. Every time students, young kids, adults, and representatives for the government want to visit the Institute, we show them the things we are doing and really showcase all the good science that we do at the Institute.

Have you had any highlights of your PhD project so far?

Baptiste: Well, I admit the first day when I arrived in the lab - I knew that I was going to work on the development of the lymphatic system in Zebra fish - but on first day it took three or four hours for my supervisor to convince me that what I was looking at under the microscope was a lymphatic system. I didn't see anything, I couldn't actually see the structures I was going to spend the next three to four years of my life on. And that was … a bit frightening! When I finally saw it, that was the most amazing feeling.

I've been trying to attend as many conferences as I could. [But] it's a week of your time that's gone, so you can't always do this, especially because the cost of attending [the] conference is a bit elevated for the lab as well. I've been going to lots of Zebra fish-specific conferences. [I have] been sent to the US during the summer to present my work. It's a stressful time really, because this is the time when you are putting your work out there. It's not published and there

are people that actually know about it. That's the moment when you've got a bit of pressure knowing, *"Okay, I'm not the only person in the world working on this, now there are other people who might be interested."* But these days I'm excited about giving talks and actually showing my work to people because I've got the chance to. You're on your own turf when you're presenting it. You can use your words and direct the attention of the audience the way you want.

Sarah giving a TedX talk in Brisbane. *Credit: Screen Capture from https://www.youtube.com/watch?v=r_VtPiOwHuo*

Any final words of advice for our readers considering doing a PhD and research as a career?

Sarah: Honours is a good way to get a taste of research. It's quite a full on year because it's half research, half course-work, so it's a good time to work out if this is something that you enjoy doing. If you're second or third year, then you can consider doing a summer project and that's also a great way to get a taste of research. And, you have a bit more time I think, not having to do courses because it's during summer which is a bonus as well. The important thing is to do something that you love, because you have passion for it and that's what keeps you going. I don't think there's a perfect job that every single day, you bounce out of bed, but if it's something you can look forward to or when you come back from holidays you can feel glad to be back, then that's something that you should pursue.

Baptiste: Particularly if you're working in developmental biology, never get stuck on one animal model because [it] might not be trendy by the time you actually start your PhD or by the time you finish your PhD there might be something new in the field. I think it's pretty a good idea that whatever sort of science you're doing try to actually study different sort of models. It's going to make it easier to present your work, because it shows that it's completely translatable and it's going to make you a more translatable person when you've got to move into a new lab that might be more focused on something else. It's like being bilingual: you are able to talk to the developmental biology tongue of different labs around the world. Always, whatever you try [to] do, try to keep aware of what is happening generally in science. I mean you don't have to do much – I follow some sort of science news, just the small snippets of science that happens, there might one or two that when you actually start to read them and realise that, "Wow, this is new, this is going to be big, I have to be part of this."

Baptiste and Sarah have now finished their PhDs. You can find them online.

Baptiste: https://www.linkedin.com/in/baptiste-coxam-82434012

Sarah: www.sarahsweet.com.au and https://www.linkedin.com/in/sarah-sweet-96a03546

The Study of Stress

Kate completed a BSc Hons at UQ. She currently works at the UQ Centre for Clinical Research.

Kate Riggall

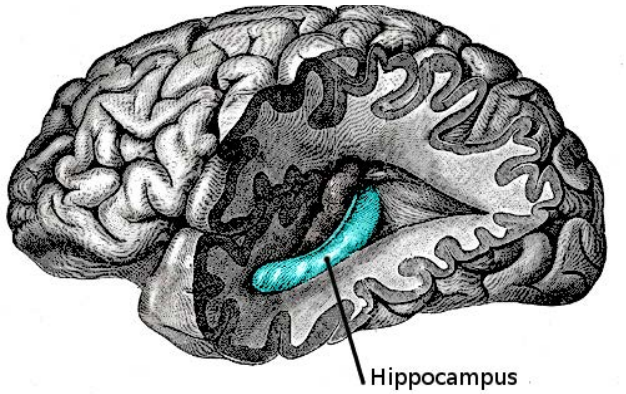
Have you ever felt that stress hinders your learning capacity? Nothing seems to stick? Don't worry, we're working on it.

It is one of the most pervasive, expensive and, until recently, under-researched diseases of our time. Yet 'stress' is so often dismissed as an inevitable part of modern life, and goes untreated.

As we all know too well, studying can be a tense, intimidating and humbling experience. University is a rite of passage in learning how to deal with stress. The problem is, stress reduces our capacity to learn. It can hinder memory formation, consolidation, retrieval, attention and motivation. Stress is the enemy of the student.

Stress is particularly interesting for researchers who are interested in 'brain plasticity' – which is a property of the brain that allows it to adapt. For instance, particular areas of the brain hold particular functions; a stroke patient may lose movement in their left arm because the area of the brain dedicated to that function was destroyed. However, as the patient undergoes rehabilitation, the lost functions can be re-localised to another area of the brain – returning left-arm movement. This adaptability is what is meant when brains are described as 'plastic'. Indeed, young children generally learn faster than young adults since children's brains are more plastic. Researchers are trying to understand the effects of stress on neural plasticity, which will hopefully help keep brains of students – at all levels – as pliable, malleable, and plastic as possible.

The 'stress response' is a phenomenon whereby the whole body reacts to a perceived threat. It is orchestrated by the neuroendocrine system (i.e., the body's long-distance signalling network comprised of the nervous system and the hormones). With the help of the hippocampal 'memory centre', the brain's fear centre – the amygdala – judges the severity of the situation.



Brain section with the hippocampus exposed. *Credit: Henry Gray (1918) Anatomy of the Human Body. Bartleby.com: Gray's Anatomy, Plate 739*

This triggers a response in the hypothalamus, which controls the release of hormones. The pituitary gland and adrenal gland are then activated almost simultaneously, secreting adrenocorticotropic hormone (ACTH) and neurotransmitter epinephrine (adrenaline), respectively. This results in the production of the hormone cortisol, which increases blood pressure, blood sugar, and suppresses the immune system. The result is a sudden burst of energy you can use to fight – or run – for your life.

The sympathetic nervous system is the driver of the stress response, whereas the parasympathetic system takes over when we are 'resting and digesting'. Once the stress response is activated, it can take a long time for the parasympathetic system to regain control – explaining why forcing yourself to relax after a stressful situation can be difficult. Indeed, the sympathetic system dominates over the parasympathetic system since, in evolutionary terms, our species' overall survival depends more closely on our ability to evade predators (sympathetic) than our ability to melt into the couch while binge-watching Netflix (parasympathetic).

Prominent researcher Robert Sapolsky suggests that since ancient humans were once regularly reliant on 'fight or flight' behaviours to survive, our genes manoeuvre us to apply these same behaviours to modern-day contexts. But the lives of contemporary humans are markedly different to the lives of our ancient counterparts. In most contemporary western societies, we don't need to anticipate a hungry lion waiting for us around every corner. Communication skills and a high emotional intelligence are more important to modern-day success. Chronic stress, says Sapolsky, has emerged as a lifestyle disease because we are genetically predisposed to applying 'fight or flight' thinking to modern problems that actually require a more nuanced, emotional approach.

Stress is a phenomenon of the neuroendocrine system (our brain, nerves and hormones), which is highly connected to other systems throughout the body. Thus it is unsurprising that stress affects a wide range of bodily functions beyond the brain and nervous system. Chronic stress can negatively influence reproduction, digestion, immunity and heart function; as well as contributing to obesity and type 2 diabetes. The latter may be fuelled by 'comfort eating' (see: Netflix). Research is even beginning to uncover links between stress and cancer, and between stress and drug addiction.

Furthermore, the area of our brain dedicated to memory formation and consolidation, the hippocampus, is particularly vulnerable to chronic stress due to its high concentration of stress receptors. While stress hormones such as cortisol form a key part of the memory process, when their levels are too high for too long they can cause long-term damage. The hippocampi of chronically stressed patients show a measurable loss of volume in magnetic resonance imaging (MRI) brain scans; this is similar to sufferers of post-traumatic stress disorder and major depression.

Exercise alleviates the effects of stress like nothing else. Many studies have shown that moderate exercise can decrease anxiety and prevent hormonal imbalance. It also alleviates oxidative stress, which is where reactive and damaging oxygen molecules are created faster than the body can get rid of them.

Mindfulness is another therapy that has made its way into the mainstream, despite originating thousands of years ago. Mindfulness is a modern reinterpretation of the Buddhist tradition, where it is now a common therapy for depression, anxiety, addiction and chronic pain – among other psychological conditions. It aims to help subjects view external circumstances as challenges rather than threats. Multiple studies have shown the effectiveness of mindfulness therapy; and though little research has been done on the cellular mechanisms involved, there is some evidence that the benefits occur through long term alterations of brain structure – which may reverse the physical effects caused by chronic stress.

Stress is a serious medical issue, and if left untreated can have a significant negative impact on learning, academic achievement and quality of life. It is important for both students and learning institutions to be aware of the causes, symptoms and treatment options.

If you are experiencing stress and would like help, UQ offers student support through Student Services (http://www.uq.edu.au/student-services/). The UQ Student Union also offers help through SHOC (http://www.uqu.com.au/student-support).

Blackleg Disease in Canola – Searching for Resistance

Ainnatul Adawiyah Ahmad Termizi

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Deploying resistance genes in canola varieties is the most effective and sustainable way to prevent blackleg disease – caused by the devastating fungal pathogen, *Leptosphaeria maculans*. Several genes have been identified as *Resistance to L. maculans 2 (Rlm2)* candidate genes. Which one is the real *Rlm2* gene?

Not only is canola seed prized for its heart-and-brain healthy properties, but the canola industry is also nourishing the Australian economy. Exports to the European Union netted Australia $550 million in 2014-15, and canola oil – which makes up 44% of the seed – has less than half the saturated fat found in olive oil and more omega-3 than in any other culinary oil.

Unfortunately, canola plants suffer from 'blackleg disease' – caused by the virulent fungal pathogen *Leptosphaeria maculans*. The blackleg fungus is harboured in canola stubble. After autumn rains the fungus grows and releases air-borne spores that travel to the leaves of other plants. As the spores germinate they degrade the plant, creating a regions of rotted tissue called cankers. Mild cankers may only limit water and nutrient flow, but severe cankers can cut the roots from the stem. Although unusual, there are cases of blackleg disease that have has decimated up to 50% of canola yields. Our goal is to understand how to make canola resistant to blackleg disease, and we are using genetics to find the answer.

Canola, or *Brassica napus*, is a hybrid of *Brassica rapa* (Chinese cabbage, pak choi, and turnip rape) and *Brassica oleracea* (broccoli, cabbage, and cauliflower). Some *Brassica* varieties possess genes that provide resistance to *L. maculans* – called R-genes. When a pathogen attacks, the R-gene products initialise localised cell death in order to prevent further infection.

Some varieties of Canola have an R-gene, called *Rlm2 (Resistance to Leptosphaeria maculans 2)*. The question is, where it is in the genome, and what is its sequence?

The ARC Centre of Excellence for Integrative Legume research (CILR) at UQ – including Dr Jacqueline Batley, Dr Jessica Dalton-Morgan, and myself – attempted to locate *Rlm2* within the *B. napus* genome. We used the *B. napus* cultivars 'Tapidor' and 'Ningyou 7'(a 'cultivar' is a variety that has been purposefully cultivated by humans). Tapidor is resistant to blackleg and its genome contains *Rlm2*; Ningyou does not have *Rlm2* and it is susceptible to blackleg.

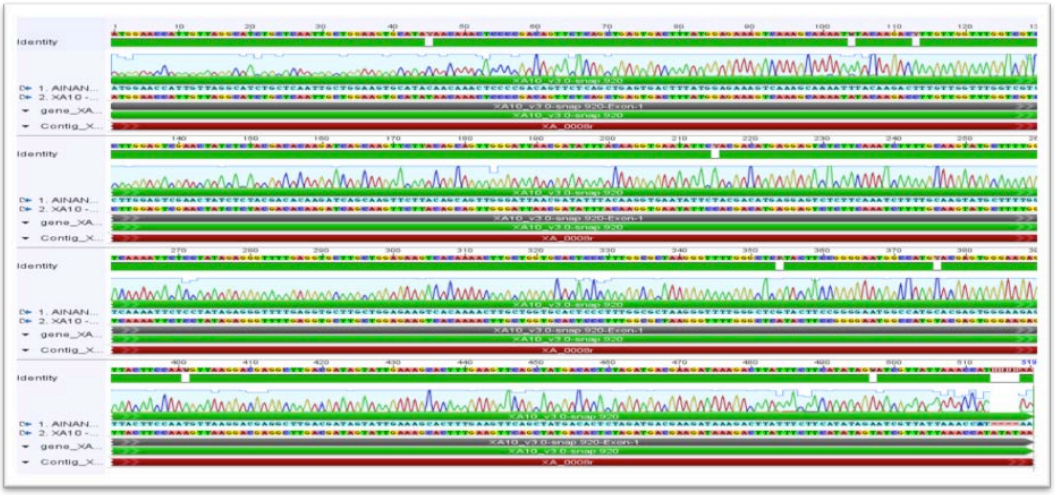
Previous genetic studies indicated that *Rlm2* is located somewhere within chromosome A10 so we compared the Tapidor and Ningyou sequences at A10 to a reference sequence, *B. rapa*, at the same location. Using the gene prediction software Semi-HMM based Nucleotide Acid Parser (SNAP), the genes SNAP 131, SNAP 693 and SNAP 920 were identified as *Rlm2* candidates due to their homology with disease resistance proteins. Unfortunately, gene amplification could only be achieved for Ningyou SNAP920; and so only Ningyou SNAP 920 was investigated in the sequence analysis.

When the Ningyou sequence was aligned with the *B. rapa* reference sequence, eight Single Nucleotide Polymorphisms (SNPs) were found (where SNPs – pronounced "snips" – are mutations of a single nucleotide). A four base-pair deletion was also observed at the 3' end of the gene, disrupting the STOP codon and thus altering the length of the coded protein. Six out of the eight SNP mutations were non-synonymous mutations – this means that the sequence of the encoded protein was altered in six places.

Pseudothecia on canola stubble
Credit: Ralf Lange https://www.flickr.com/photos/38656566@N00/

If a functionally important sequence undergoes a non-synonymous mutation, the organism's evolutionary fitness will more likely decrease rather than increase. Natural selection will weed out those organisms who experience non-synonymous mutations within functionally important sequences. Therefore, if a sequence exhibits more non-synonymous than synonymous mutations, it is likely that the sequence is functionally unimportant. On the other hand, functional sequences exhibit more synonymous mutations because natural selection will favour silent mutations within important sequences.

Given that blackleg disease represents a significant threat to the Brassicaceae family, *Rlm2* must confer an evolutionary advantage to those varieties that possess it. Therefore, the real *Rlm2* sequence should show more synonymous mutations compared to non-synonymous mutations.



Complete coding sequence of SNAP 920. *A comparison between B. napus Ningyou and the B. rapa reference sequence is shown (created in Geneious Basic 6.0.4).*

Given that blackleg disease represents a significant threat to the Brassicaceae family, *Rlm2* must confer an evolutionary advantage to those varieties that possess it. Therefore, the real *Rlm2* sequence should show more synonymous mutations compared to non-synonymous mutations. Ningyou SNAP 920 in fact shows the opposite – excess non-synonymous mutations – thus it is unlikely that Ningyou SNAP 920 is *Rlm2*.

Future studies should employ expression analyses using quantitative real time PCR to verify whether SNAP 920 responds to an *L. maculans* attack. Furthermore, transforming the candidate genes into susceptible varieties or knockout mutations would reinforce confidence in these results. Although the Tapidor cultivar could not be investigated, this study successfully characterised the differences between the *B. rapa* and the *B. napus* Ningyou SNAP 920 genes.

Ainnatul was supervised by Dr Jessica Dalton-Morgan and Associate Professor Jacqueline Batley at the The ARC Centre of Excellence for Integrative Legume Research (CILR), The University of Queensland.

Field of Canola. *Credit: Massmo Relsig https-//www.flickr.com/photos/99574551@N04/*